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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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VOL. XIX, No. 2 MARCH-APRIL, 1925 WHOLE No. 146

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THE JOURNAL

OF THE

ROYAL ASTRONOMICAL SOCIETY

OF CANADA

Vol. XIX MARCH-APRIL No. 2

THE ANNUAL GENERAL MEETING OF THE SOCIETY HELD IN THE PHYSICS BUILDING OF THE UNIVERSITY OF TORONTO, JANUARY 13, 1925, AT 8 P.M.

A. F. Hunter, M.A., Second Vice-President, in the chair.

The Minutes of the last Annual Meeting as they appeared in the Society's JOURNAL were accepted as read.

The Election of Officers and Members of Council was proceeded with, the ballots were opened and counted with the following results:

Honorary President: Hon. G. H. FERGUSON, K.C., B.A., LL.D., Minister of Education for Ontario, Toronto.

President: R. M. STEWART, M.A., Ottawa.

First Vice-President: WM. BRUCE, J.P., Hamilton.

Second Vice-President: A. F. HUNTER, M.A., Toronto.

General Secretary: F. T. STANFORD, Toronto.

General Treasurer: H. W. BARKER, Toronto.

Recorder: GEORGE M. BRYCE, B.A.

Librarian: PROF. C. A. CHANT.

Curator: ROBERT S. DUNCAN.

Council: MGR. C. P. CHOQUETTE, M.A., Lic.Scs., Montreal; J. B. FRASER, M.D., Toronto; R. A. GRAY, B.A., Toronto; A. R. HASSARD, B.C.L., Toronto; J. H. HORNING, M.A., Toronto; DR. RALPH DELURY, Ottawa; PROF. JOHN MATHESON, M.A., Kingston; SIR JOSEPH POPE, K.C.M.G., Ottawa; JOHN SATTERLY, M.A., D.Sc., Toronto; DR. W. M. WUNDER, Toronto.

The General Secretary's Report was read and accepted.
The General Treasurer's Report was read and accepted.
The Librarian's Report was read and accepted.
The Auditor's Report was read and accepted.

Mr. A. R. Hassard and Dr. Fraser were thanked for their services and appointed auditors for the ensuing year.

The Auditors recommended an increase in the Library insurance and that further details regarding the Society's instruments be given in the reports.

Report of the General Secretary for 1924

During the past year there have been reported to the Society 45 meetings held under its name and auspices in various parts of the Dominion, as follows:

Victoria	8
Montreal	4
Toronto	20
Ottawa	5
London	8
Winnipeg	10
	55

There have been three meetings of the Council, namely, February 15th, June 20th, and November 13th, 1924.

The reports from the various centres, as printed in the Journal, have been many and varied. Continued interest in astronomy is evidenced by these reports, and the papers and addresses have been of a high order.

Our membership numbers 526 as compared with 556 for previous year.

The following table gives the membership for 1924 as shown by the Society's mailing list of January 1st 1925:

Toronto City	111
" Outside	136
Hamilton	11
Ottawa	65
Victoria	52
Winnipeg	49

Montreal	61
London, Ont	41
Total	526

In addition to these ordinary members there are 20 paying subscribers, 12 Life Members and 15 Honorary Fellows.

Anyone who has observed the newspapers, and attendance of the general public at meetings of the Society, cannot help being impressed with the fact that Astronomy is taking a great hold upon the people generally, and with renewed effort this Society should, during the present year, be able to turn this interest to good account by increasing our membership and extending, if possible, the number of our local centres. The efforts of the Council are being directed to this end.

The following papers and addresses were read or delivered at the meetings in Toronto:

Jan. 29—W. E. W. Jackson, M.A.—A Review of Astronomy during 1923.

Feb. 12—Prof. Henry N. Russell—The Size and Extent of the Universe (Jointly with the University of Toronto course of lectures).

Mar. 11—Mr. J. R. Collins—The Constellation Ursa Major.
Prof. C. A. Chant and A. F. Hunter—The Dark Nebulae and their reversal.
Mr. A. F. Miller—Interferometer measurements of stars, nebulae and novae.
Prof. C. A. Chant—Incidents in the Life of Sir William Herschell.

Mar. 25—Arthur Kennedy—The Constellation Gemini.
William Gore, F.C.G.L.—A New Theory of Gravitation and Matter.

Apr. 8—Mr. A. F. Miller—The Constellation Gemini.
Mr. S. C. Brown—The Constellation Canis Major.
Sir Frederic Stupart, F.R.S.C.—The Weather of the Past Winter.

Apr. 22—Mr. A. F. Miller—The Constellation Scorpio.
A. R. Hassard, B.C.L.—The Approaching Transit of Mercury (May 7).

May 6—Mr. F. T. Stanford—Means of Advancing the Interests of the Society.
H. F. Balmer, M.A.—The Nature of the Nebulae.
May 20—Mr. J. R. Collins—The Constellation Sagittarius.
A. F. Hunter, M.A.—The Astronomical Work of Major Holland, Surveyor-General of Canada.
Oct. 14—W. E. W. Jackson, M.A.—Sun spots, solar activity and magnetic activity in 1924.
Mr. A. F. Miller—Observations on the planets Mercury, Venus, Saturn, Jupiter and Mars.
Mr. F. T. Stanford—Recent magazine information in astronomy.
Oct. 28—A. F. Hunter, M.A.—The New (Bombardment) Theory of the Aurora.
Prof. C. A. Chant—Astronomy at the British Association, 1924.
Nov. 11—Mr. A. F. Miller—Results of Observations of Mars during the 1924 opposition.
Dr. A. D. Watson—Proposed Calendar Changes.
Nov. 25—John A. Paterson, M.A., K.C.—The Development of Astronomical Theory.
A. R. Hassard, B.C.L.—Daylight Saving Time.
Dec. 9—R. K. Young, Ph.D.—The Total Solar Eclipse, January 24, 1925.
Prof. C. A. Chant—The Change of the Astronomical Day, beginning in 1925.

F. T. STANFORD, *General Secretary.*

FINANCIAL STATEMENT FOR YEAR ENDING DECEMBER 31, 1924

Receipts

Cash in Imperial Bank, Dec. 31, 1923	$ 395.43	
Grant from Dominion Government	2,000.00	
Grant from City of Toronto	100.00	
University of Toronto (50 Journals)	100.00	
Fees of Members	967.75	
Interest on Bank Account	42.01	
Sundry Receipts—Sale of Magazines	167.83	
		$3,773.02

Disbursements

Publications JOURNAL, HANDBOOK and Printing	$2,134.81	
Public Meetings	226.35	
Library account, books, etc	109.66	
Stationery, stamps, etc	251.17	
Salaries (Assist. Librarian and caretaker)	430.00	
Rent of Rooms	120.00	
Grants—Montreal Centre	84.00	
Ottawa Centre	91.50	
London Centre	86.25	
Winnipeg Centre	63.00	
Victoria Centre	108.00	
Miscellaneous Expenses	57.82	
Balance in Bank	10.46	
		$3,773.02

H. W. BARKER, *General Treasurer.*

Certified correct,
Jan. 9, 1925.

A. R. HASSARD,
JNO. B. FRASER,
Auditors.

BUILDING ACCOUNT STATEMENT

Receipts

Cash in Imperial Bank, Dec. 31, 1923	$ 746.43
Interest on Investments	110.00
Interest on Bank Account	22.97
	$ 879.40

STATEMENT OF BONDS HELD BY IMPERIAL BANK

Canada Permanent, 5½%	$ 500.00
Canada Permanent, 5½%	500.00
Dominion of Canada Victory, 5½%	$1,000.00
	$2,000.00

Librarian's Report for 1924

During the year 1924 nothing requiring special notice occurred in the Library. It is steadily increasing in size and completeness, chiefly by the addition of periodicals and publications of observatories. A few books were purchased and sixteen volumes were bound.

The following statistics may be found of interest.

Periodicals received during 1924:	
From Canada and the Empire	223
From the United States	193
From other countries	189
Total	605
Exchange list:	
Canada and the Empire	43
United States	55
Other countries	47
Total	145

It is hardly necessary to state again that the accommodation for the library is far too small. It would be much more consulted if it were properly housed.

C. A. CHANT.

Montreal Centre

The following addresses were given during the year:

Feb. 28—"The Moon has no Atmosphere—Why?" by Mgr. C. P. Choquette.

Mar. 28—"The Riddle of the Stars," by A. Vibert Douglas.

Apr. 24—"The Influence of the Sun and the Moon on the Ocean", by Dr. Bell Dawson, F.R.S.

Nov. 21—"Making Discoveries in Astronomy," by Dr. R. K. Young.

(At joint meeting with the McGill Physical Society and Sigma Xi).

At the Annual Meeting on November 21 the following officers were elected for 1925:

Honorary President: Mgr. C. P. Choquette.
President: Justice E. E. Howard.
First Vice-President: Dr. A. S. Eve, F.R.S.
Second Vice-President: Prof. A. H. S. Gillson.
Treasurer: Prof. A. J. Kelly.
Secretary: Miss A. Vibert Douglas.
Council: H. E. Asbury, J. L. Clarke, W. E. Lyman, Geo. Sample, Julien C. Smith.

Financial Statement for 1924

Receipts

Balance on hand in Bank, Dec. 12, 1923	$136.92	
Seven (7) Members' Fees for 1923	14.00	
Forty-two (42) Fees for 1924	83.92	
Forty-seven (47) Fees for 1925	94.00	
Grant from General Treasurer	83.85	
Bank Interest on Deposits	5.26	
		$417.95

Disbursements

Remitted Fees to General Treasurer	$ 98.00	
Postal Order to Toronto, Jan. 15, 1924	8.07	
Expenses of Lectures	44.15	
Printing and Stationery	7.25	
Postage	11.50	
Janitor and Lantern Service	21.00	
Balance on hand in Bank, Dec. 31, 1924, including $94.00 fees in advance	227.98	
		$417.95

Ottawa Centre

Report of Secretary, 1924

During the past year the following programme of lectures was given:

Jan. 29—"The Structure of the Atmosphere"—John Patterson, M.A., Meteorological Service, Toronto.

Feb. 26—"The Planetismal Hypothesis"—T. L. Tanton, M.A., Ph.D., Geological Survey of Canada.

Mar. 11—"Heat and Light from the Stars"—Howard T. Barnes, D.Sc., F.R.S., McGill University.

Mar. 25—"The Sun and Meteorites"—R. E. DeLury, M.A., Ph.D., Dominion Observatory.

Apr. 23—"The Size of the Universe"—Dr. Ludwik Silberstein, Eastman Kodak Company, Rochester, N.Y.

The lectures were well attended and the public seemed to have a real interest in the activities of the Society. The Society appreciates the part the city newspapers have played in creating this interest, not only by the splendid reports of our meetings but by timely articles previous to the lectures. It was a matter of regret that Dr. Silberstein, after coming to us from Rochester, was obliged to return home the day before his lecture on account of illness.

The following list gives the present standing of the Society:

New members elected during the year	9
Members resigned during the year	1
Members transferred (Toronto Centre)	1
Total membership. Dec. 31, 1924	65

A. H. MILLER, *Secretary*.

The postponed Annual Meeting of the Ottawa Branch of the Royal Astronomical Society was held in the Victoria Museum on Friday, January 24, 1925, at 8 p.m., following a short address by Dr. R. E. DeLury on the coming solar eclipse.

The reports of the Secretary and the Treasurer for the past year were presented and adopted, and the election of officers for the year 1925 was proceeded with, resulting as follows:

President: C. R. COUTLEE, C.E.
Vice-President: H. M. AMI, D.Sc.
Secretary: A. W. GRANT, B.A.
Treasurer: J. F. FREDETTE, D.L.S.
Council: W. W. NICHOL, M.A.; W. S. MCCLENAHAN, B.A.; F. HENROTEAU, D.Sc.; and *Past Presidents:* R. MELDRUM STEWART, M.A.; J. J. MCARTHUR, D.L.S.; R. E. DELURY, M.A., Ph.D.; and R. J. MCDIARMID, M.Sc., Ph.D.

Treasurer's Report for 1924

Jan.	1—Balance on hand	$27.33
Jan.	1—Bank Interest	2.36
Mar.	1—Grant from Gen. Treas	91.50
June	30—Bank Interest	1.34
		$122.53

Expenses

Lecturer's expenses	$ 42.00
Printing	10.84
Press notices	28.00
Postage and other items	17.29
Flowers	5.00
Cr. Balance	19.40
	$122.53

W. S. McCLENAHAN, *Treasurer.*

Examined and found correct,
D. ROBERSTON,
Dec. 31, 1924.

LONDON CENTRE

Secretary's Report

During the year 1924 eight regular meetings were held. These were well attended and interest in the study of Astronomy has been well sustained. The following addresses were given during the year:

Jan. 11—"The Recent Total Eclipse of the Sun." Illustrated by moving pictures taken on the Island of Catalina and in Mexico. Dr. H. R. Kingston.

Feb. 8—"Mars as the Abode of Life." Illustrated. Dr. E. J. White.

Mar. 14—"Clocks, Ancient and Modern." Dr. H. R. Kingston.

Apr. 10—"Seasons on the Earth and on the other Planets." Illustrated. E. H. McKane, B.A.

Oct. 10—"The Earth as an Astronomical Body" (First Lecture). Dr. H. R. Kingston.

May 7—On this date a successful observations meeting was held on the Normal School grounds, when observations were made of the transit of Mercury across the sun's disk.

The officers for 1925 are:

President: H. R. KINGSTON, M.A., Ph.D., F.R.A.S.

Vice-President: MRS. W. E. SAUNDERS.

Secretary-Treasurer: E. J. WHITE, B.A., D.Paed.

Councillors: REV. R. J. BOWEN, F.R.G.S.; MR. T. C. BEWSON; MRS. J. C. MIDDLETON; MR. W. A. MCKENZIE; MR. E. H. MCKANE, B.A.

E. J. WHITE, *Secretary.*

Financial Statement for 1924

Receipts

Balance carried forward	$21.31
Fees paid in advance	12.00
Grant from General Treasurer	86.25
Refund from Dr. Kingston	1.00
Fees for 1924 (34 members)	68.00
Interest on deposits	1.68
Total	$190.24

Disbursements

Caretaker	$ 5.00
Rent for dishes	1.50
Remitted to General Treasurer	80.00
Printing	17.20
Postage and Stationery	3.10
Expense removing Pictures	20.62
Cash balance in Bank	62.82
Total	$190.24

Audited and found correct,

E. J. WHITE, *Treasurer.*

J. C. MIDDLETON
THOS. COLERIDGE } *Auditors.*

Victoria Centre

Report of the Secretary for 1924

Owing to the illness of the Secretary, Mr. F. Moore, the preparation of the following report has devolved upon the Secretary for the incoming year.

The local centre has had a successful year, six council and eight ordinary meetings were held, at which the attendance was good. Eight new members have been elected, and two removed from the roll, leaving a membership of 72.

In addition to the regular meetings the Society united with the Vancouver Island Prospector's Association on one occasion to hear Dr. E. M. Burwash of Victoria College lecture on the "Planetesimal Hypothesis." A large number of the members and their friends attended the open-air meeting on July 8, and good use was made of the 8-in. reflector and the two smaller refractors. The interesting exhibit of various astronomical and physical apparatus was greatly appreciated.

The following lectures were given during the year:

Jan. 24—"Life of Copernicus," by J. Duff.
Feb. 21—"The Planetesimal Hypothesis," by Dr. E. M. Burwash.
Mar. 20—"Science and its Relation to Religion and Philosophy," by H. H. Plaskett.
May 22—"The Spectrum," by Prof. P. H. Elliott.
July 8—Observation evening at Victoria College. Exhibit of astronomical and physical instruments.
Oct. 16—"The Planet Mars," by W. H. Christie.
Nov. 25—"The Evolution of the Stars," by Dr. J. S. Plaskett.
Dec. 19—Annual Meeting, "A Review of Astronomy for 1924," by J. Duff.

The officers for 1925 are:

Honorary President: J. S. Plaskett, D.Sc., F.R.S.
President: J. Duff, M.A.
Vice-President: F. Moore.
Treasurer: J. P. Hibben.
Secretary: J. A. Pearce, M.A.

Council: K. M. CHADWICK, R. G. MILLER, P. H. ELLIOTT, M.Sc., E. E. BLACKWOOD, and the Past Presidents F. NAPIER DENISON, W. S. DREWRY, J. E. UMBACH and W. E. HARPER, M.A.

J. A. PEARCE, *Secretary*.

Jan. 1, 1925.

Treasurer's Statement for 1924

1923			
Dec. 31—Balance in Bank		$48.16	
Cash on Hand		.70	
			$48.86
Receipts			
1924			
Apr. 30—Interest		$ 1.20	
Oct. 30—Interest		2.30	
Mar. 5—Grant from Toronto		108.00	
Mar. 3—Mr. Kitto half Printing Account		3.75	
June 17—From Members at Luncheon		9.00	
2 Subscriptions for 1922		4.00	
11 Subscriptions for 1923		22.00	
29 Subscriptions for 1924		58.00	
2 Subscriptions for 1925		4.00	
			$212.25
			$261.11
Expenditures			
1924			
Jan. 7—Ritchie Press		$ 9.75	
June 14—Colonist Press		12.72	
June 14—Times Press		1.33	
July 8—P. A. MacLean (High School)		2.50	
June 18—D. Spencer		10.00	
Aug. 1—Victoria School Board		17.50	
Sept. 25—Quick Press		7.00	
Sept. 30—Colonist Press		14.55	
Oct. 5—Jas. McBryer (Victoria College)		2.00	
Nov. 19—H. B. Clark		20.00	

Nov. 20—Jas. McBryer	2.00	
Nov. 26—Colonist	13.50	
Nov. 26—Jas. McBryer	2.00	
Nov. 27—Postage Stamps for Accounts	1.50	
	$116.35	
Balance in Bank	144.76	
		$261.11

Audited and found correct,
H. H. PLASKETT,
Dec. 19, 1924.

WINNIPEG CENTRE

List of Meetings and Subjects of Lectures—1924:

Jan. 9—"Life in Other Worlds," Dr. R. C. Wallace.
23—"Influence of Astronomy on the Life and Religion of Egypt," Rev. A. E. Hetherington.
Feb. 13—"Sight-seeing among the Stars," Prof. L. A. H. Warren.
27—"Giant and Dwarf Stars," Fr. T. W. Morton.
Mar. 12—"Important points to observe in the use of a Telescope," H. B. Allan.
April 9—"The Bible Stars and Constellations," Rev. Dr. Westgate.
Oct. 29—Opening Meeting—"Time" by Fr. T. W. Morton.
Nov. 12—"Mars," C. E. Bastin, B.A.
26—"Some Considerations in regard to the Structure of the Universe," H. B. Allan.
Dec. 17—"Presidential Address," Fr. T. W. Morton.

The officers for 1925 are:
President: REV. T. W. MORTON, B.Sc.
Vice-President: MRS. E. L. TAYLOR.
Curator: DR. L. A. H. WARREN.
Secretary-Treasurer: MR. H. B. ALLAN, 731 Jessie Ave., Winnipeg.
Councillors: DR. N. B. MACLEAN, MRS. S. C. NORRIS, MR. D. P. MORSE, C.E., DR. N. R. WILSON, MR. J. H. KOLB and MR. CECIL ROY.

THE SPECTROSCOPIC BINARY 12 LACERTAE

By R. K. Young

Since the determination of the orbit of this binary by the writer in 1916 the star has been observed every season and its orbit more fully investigated. The spectrum goes through very peculiar changes as announced in 1918 and later publications.

I decided, in 1924, that it would be of interest, in view of the great number of spectrograms on hand of the star, to rereduce all the measures and to make a special table to represent as accurately as possible the wave-lengths of the lines in the star. Mr. W. H. Christie of the Victoria Observatory undertook the work connected with the rereduction. On examining the older measures made in Ottawa and those made in Victoria, my attention was drawn to the wave-length used for the calcium line K 3933.727. When the first orbit was determined at Ottawa no suspicion was entertained that the calcium lines were peculiar, and it was the custom to alter the wave-lengths for each binary to make the lines harmonize as well as possible. Later, in 1918, when the peculiar behaviour of the calcium lines was discovered, the fact that the original measures were reduced with the altered wave-length was overlooked. The correction of this oversight makes an important change in the velocities derived for the calcium lines.

I announced the following results for the velocity of the system derived from the hydrogen and helium lines and from the calcium lines:

	1913	1914	1915	1918
H and He	−8.5	−11.2	−15.6	−19.1
Ca	−8.0	− 9.1	−11.2	−17.7

On the basis of these results it appeared that the velocity of the centre of gravity of the calcium cloud was moving with the other lines, a result which had a most important bearing on the theory of these stars, and forced me to believe that the calcium envelope was closely associated with the central star. With the corrected wave-lengths this table becomes, later results being incorporated also.

	1913	1914	1915	1918	1919	1920	1921	1922	1923
H and He	− 8.5	−11.2	−15.6	−19.1	−19.5	−17.5	−16.6	−11.0	−13.2
Ca	−15.5	−16.6	−18.7	−17.7	−15.6	−11.9	−15.3	−13.9	−14.7

Thus we see that most of the evidence for the variation of the calcium lines with the other lines, though possibly not all, is removed. With the exception of the value in 1920, the results might be interpreted as showing a constant value for the calcium lines. The star is thus brought in harmony with the growing evidence that the calcium clouds surrounding those stars showing the narrow absorption is in the nature of a general cloud of great extent.

Toronto,
March, 1925.

TIME COMPARISONS BY COINCIDENCE

By J. P. Henderson

Clocks or chronometers may be compared directly by means of coincidences when their rates are considerably different, or by an intermediate differentially rated one when their rates are the same, or nearly the same. Similarly a clock may be compared with outside signals, such as wireless time signals, by this means. Some precision may be obtained by observing merely the coincidence of audible beats made of about the same intensity for the ear, but there is liable to be a personal equation with different observers.

When considerable precision is required clocks may be compared by the method of coincidence by extinction, when one series of audible signals is gradually encroached upon and finally extinguished by another series of "opens" during each of which no signal is heard. In this case personal equation appears insignificantly small or absent entirely; it remains only for the observer to determine whether at a given point there is any signal at all.*

By this method, when two clocks or chronometers are to be compared, one is connected electrically so that it produces an audible signal, such as a buzz every second. The differently rated chronometer by means of its electrical contacts opens the circuit at every one of its own seconds, keeping it open for a sufficient time to more than extinguish the whole of the buzz signal from the first.

The audible signal may be produced by an electrical tuning fork, motor commutator, a.c. induction, audio vacuum tube oscillator or buzzer, or other suitable means, but should be of high pitch that the time from one peak of the alternating or intermittent electric wave to the next will be small in comparison with the degree of accuracy it is desired to obtain in the comparison. We have found experimentally that for most observers a succession of

*This principle was first suggested by W. E. and F. B. Cooke in 1917. See M.N. 77, p. 469.

at least two maximum excitations separated by an audio pitch interval is sufficient to give a sense of musical pitch and to be distinguished by this means from static, or accidental clicks. This does not mean that an untrained observer can immediately match the musical pitch when only two or three such occur in regular succession—though this may sometimes be done by an experienced one—but they can be recognized as a signal.

To be sure that these necessarily full maxima occur from the very beginning of the signal the source of oscillation should be operating continuously, giving full strength of the musical pitch; but its output may be short-circuited by a relay connected to the chronometer till the moment the chronometer breaks circuit, when the relay opens and the signal commences immediately, no time being required for it to build up to full strength. It can be shown that the shortest signal that can be distinguished will be less than twice the audible pitch period; for example, if the oscillator is giving a pitch of 500 cycles per second, a signal of about 0.004 sec. duration may be detected, and the probable error from this source judged accordingly. This was investigated by using a stylus attached to the diaphragm of a sensitive telephone receiver which gave a visible record of the audio signals on smoked paper on a rapidly rotating chronograph drum. Amplified wireless signals could be thus recorded along with clock clicks, etc. Ear coincidences or obliterations of the signals were also made, and these were compared with the smoked-paper records and showed satisfactory accordance to bear out the above conclusion.

In the receipt of wireless signals there was employed for some years a chronometer rated to gain about 15 minutes per day on mean time, giving a coincidence with mean time signals about every 96 seconds, three coincidences occurring during the five-minute time-signal period. This rating was chosen so that two coincidences could not occur during 55-59 second break periods in the U.S. time-signal system. A choice of one second either way in estimating a coincidence would change the result as obtained from that coincidence by about 0.01 sec.; the time of coincidence is estimated to 0.5 sec. and the mean of the three estimations taken.

Latterly, a chronometer with a gaining rate of about 30 minutes per day has been in use, which gives a slightly larger probable

error for each individual coincidence, but allows about six during the five-minute period. This gives more observations, and more opportunities in case of partial failure of the transmitted signals, as well as giving a fair comparison with stations sending time only one or two minutes, when the other rate might prove entirely useless. This rating is approximately that of the "rhythmic" signals now emitted by many wireless stations. A choice of one second more or less for the coincidence epoch makes an alteration in the comparison of 0.02 sec. for that observation; the coincidence is estimated to 0.5 sec. on the face of the chronometer—distinguishing the case where the exact point of extinction occurs just on one of the beats or between two, when one of the beats is distinct but shorter than it would have been had the coincidence occurred precisely on the other beat.

With the U.S. system, where dots of about 0.25 sec. to 0.35 sec. duration are transmitted every second, the chronometer rated as above to gain about 30 minutes per day is used, the contact being arranged to open and close on alternate half seconds. It is compared chronographically (or occasionally more conveniently in the field by a similar coincidence method) with the standard or observing clock or chronometer both before and after the time signals are received, its relative rate over this short interval being used in the reduction. The moment when the signals have just disappeared (the "opens" have been creeping forward from the ends of the signals till they finally extinguish them completely) is the coincidence point, and the reading of the local chronometer at this moment is noted. Also the approximate readings of the chronometer at certain specified beats, say the 30th or 60th beats of each minute, are noted; using these, the beat of the outside signal corresponding to that of the chronometer at coincidence can be found, knowing that the chronometer gains on the incoming signal. The mean of all six, or as many as are obtained, is used. It is a simple matter of interpolation to reduce this and find the reading of the standard clock at the same moment, using the measured rate of the gaining chronometer over the interval.

In the accompanying diagram (Fig. 1) ten wireless signals are represented in the first line by dashes each 1/3 second long; 11 seconds of the comparison chronometer are shown on the second

line, this clock for convenience being assumed to gain one second in every ten on the incoming signals, the intervals when its circuit is closed being represented as blocks each 9/20 second long. The breaks are clear of the signals, for the first two seconds, and this represents a time when the full signal is heard. As we advance along the line, at the third second the last part of the signal is

Fig 1.

beginning to be cut off by the opening of the relay. Only a small part of the beginning of the fifth signal remains, and none of the sixth, the coincidence being considered to occur in this case at 5.5 seconds. For two seconds no signal is heard, then it begins to reappear, the last of the 7th signal appearing first, till at the 10th the whole signal is again heard, and the process begins to repeat itself. With the rate actually used the sequence of events is the same, but occupies about 50 seconds. When the relative rates are reversed as they are in the case of Lafayette, Nauen, etc., when these are compared with a sidereal chronometer, the first appearance of the signal marks the moment of coincidence, this being the emersion of the beginning of the signal from obscuration.

The rhythmic signals sent out from several stations are themselves rated to gain about the same as the chronometer spoken of above—the whole series of say 300 beats extending over about 4m 53s., during which about 6 coincidences are obtainable with a regular sidereal chronometer having seconds' breaks. Actual rates as found have been: Honolulu (NPM) .98258, Lafayette (LY) and Lyons (YN) .98077, and Nauen (POZ) .9795 of sidereal time. The first appearance of the signal (or a shade before this), as the "opens" of the relay creep ahead in the series, is taken as the moment of coincidence, this then being the exact time the beginning of the incoming signal coincided with the beginning of the local chronometer break. The position of the marking beats (60th or 61st, etc.) is also noted, so that the beat number corresponding to the chronometer time of coincidence can be found.

When the wireless signal is sent on double wave and the beats are of sufficient duration it is possible to tune to the back wave

and note the disappearance—or with the U.S. signals the appearance —of the signal, being the coincidence of the end of the spacing wave with the end of the closed interval of the local relay. The local clock relay may be inserted so that it shorts the phones or radio set when it is closed, giving a back wave effect in the local circuit. Some interesting results were obtained in this manner with various combinations, using sometimes some coincidences one way and some the other of the same series, showing not only the shortness of the time required for the wireless signal to build up both in the transmitter and the receiver, but also the small probable error of the coincidence method due to the agreement of the results.

A chronometer, relay and battery may be considered as a unit and the breaks on this relay used in all cases instead of the actual chronometer beats; in fact this is what is always actually done in the chronographic method. This also gives margin for adjusting the length of the breaks or in reality the time of return of the armature to the relay magnets—either by air gap distance, or spring tension, or by inductive or condensive reactance in circuit with the magnets to affect the time of return of the magnetic field to full strength in the relay. For instance, a large iron core inductance in series with the magnets will cause the current in them to build up very slowly, hence lengthening out the "open" of the relay.

The local circuit is placed so that when the relay is open no signal is heard (except where special comparative results were sought for some special purpose as mentioned above). This may be done by locating it in many parts of the receiving set, such as in series with the phones themselves (in which case some balance on the phone terminals is generally necessary to compensate for capacity effect producing a weak residual signal even though the metallic circuit is open), or in part of the amplifying system, heterodyne, or in the aerial or radio frequency circuit. The aerial is the most convenient and satisfactory, but it will be apparent that if the complete series of outside signals is required intact for some purpose, such as automatic relay recording, it is advantageous to avoid duplicating receiving sets with their probability of heterodyning each other, etc., and to place the relay for the audible coincidences in a side circuit which can be operated without affecting the main power input to the recording relays.

When the local relay is used to open the aerial circuit it should be placed in series with the ground lead so that the aerial may come directly to the radio set and not be encumbered with the additional capacity of the local electrical system, which may then be conveniently placed on or near the ground in a tent without difficulty in tuning. If the receiving set is ordinarily well designed it will be completely detuned for the time signals and practically no sound will be heard when the relay is open. A three coil set is preferable, as with a single circuit receiver there is often a distinct click when the circuit is opened or closed; or if the relay is placed in the phone circuit the whole combination should be in a shunt such that there will be no direct current component started or stopped by the action of the relay; any such click is undesirable and there should be practically no sound produced in the phones by the opening or closing of the relay. The capacity of any outside wiring attached across the points of the relay when the comparison is being made should be kept small (it is better to have none but the aerial to ground system connected) to ensure absolute detuning; otherwise some other radio station's signals may be heard when the relay is open, on account of the insufficient detuning if a self-heterodyning set is used, or weak residual time signals themselves if a separate heterodyne is employed. Tuned radio frequency amplification and a separate heterodyne give better control and are very desirable for close double wave stations like Annapolis.

For field use this equipment is eminently satisfactory and portable. Signals that can be heard at all through static or interference can generally be used; good time comparisons can be made with stations that at the time are unreadable; any hour of the twenty-four can be used if the station can be heard, whereas it would sometimes be necessary to select certain periods of less disturbance and stronger signals if relay recording were depended upon.

In the accompanying diagram (Fig. 2) of the circuits which are in use at Ottawa the aerial is showing feeding a honey-comb (or duolateral) coil tuned with a variable condenser to the wavelength of the signal. The local comparison chronometer is connected to a relay whose points are in the ground circuit and when

open prevent any signal being heard. A double-pole double-throw switch serves to throw this relay to the chronograph circuit for making the comparison with the local standard clock before and after the reception of the signals.

Coupled loosely with this tuned aerial coil is another, also tuned, in the grid circuit of a tube suitable for radio frequency amplification, and containing in its output or plate circuit a coil tuned with a variable condenser, but having a variable resistance of the order of 500 ohms in series with the condenser, which can prevent this completely tuned (hence regenerative) amplifier from oscillating at the radio frequency. Coupled to this is the tuned grid circuit of a detector tube, also with coupling to the output (a honeycomb coil) of a heterodyne so that the two frequencies may be superimposed and produce a suitable audio pitch.

The heterodyne itself is a separate unit with two honeycomb coils, one of which (the grid) is tuned with a variable condenser; the plate circuit not being tuned, different sized coils may be inserted in series between the tickler and its filament return for different strengths of coupling to the receiving set without appreciably affecting its wave-length calibration.

The detector tube in turn passes on the signal through an iron core intervalve transformer to the next tube; if a condenser (possibly variable) is added as shown, much of the radio frequency power which would otherwise be lost may be utilized in the second tube, acting also as detector, making the system a combined radio frequency and audio frequency amplifier, in which case the tubes and transformer have to be more carefully selected and properly biased (one or more dry cells, if necessary, next the filament in the grid lead), but often the results will repay though the adjustments will be more critical.

As there is considerable inevitable coupling among the separate units they should be as far separated from each other as practicable, several feet apart; also the direction of the coils themselves should be chosen; when properly located, and efficient coils and variable condensers used, and with good insulation, the system is capable of great selectivity in tuning; excellent control of the beat pitch is obtainable with the separate heterodyne. If screening is resorted to it is with great loss in signal strength and selectivity due to the

induced current set up in any conductors in proximity to the coils. It is much better to trust to proper location of the coils at sufficient distances from each other; the influence of one coil on another may be tested by a suitable powerful screened receiving set along with a screened oscillator, and if done on the wave-length it is desired to work on, one or other of the coils may be moved by hand till a minimum of the undesired coupling is obtained. The size of the coils will depend on the wave-length it is desired to receive; 1,500 turns duolateral along with .001 mfd. variable condensers are suitable for receiving NSS, LY, POZ, etc., and are used in all places except in the aerial, where the size of coil will depend on the characteristics of the aerial, and also in tickler and coupling coils where smaller ones (say 750 turns) are used.

For field stations where only the stronger stations are to be used a single circuit receiver is often sufficient—one which has been used largely weighs only a few ounces and can be carried in the pocket. If necessary a stage of tuned radio frequency amplification may be added, such as a similar single circuit receiver without bypass phone condenser, connected directly ahead of the other receiver.

WIRELESS TIME SIGNALS AT OTTAWA

Wireless Station—NSS
Sidereal Clock—R_2 412
Comparison Clock—Dent 52865

Date—Jan. 10, 1925
Time—Noon
Observer—J. P. H.

Clock	Station
23 12 25.0	11 56 0
13 26+	57 0
14 27+	58 0
15 28+	59 0
16 30.	12 0 0

Clock	Station
23 11 36.5	11 55 12.5
13 13.5	56 47.5
14 1.5	57 34.5
14 50.5	58 22.5
15 39.5	59 10.5

Comparison Clock	Sidereal Clock
23 8 4.5	19 8 1.979
	1.0758
18 4.5	17 51.221

Comparison Clock	Wireless Station	Sidereal Clock
23 13 52.3	11 57 25.5	19 13 43.543
		19 13 20.106

EAH 2000
8/3/24

App. ΔT = −23.44

WIRELESS TIME SIGNALS AT OTTAWA

Wireless Station—LY
Sidereal Clock—R_2 412
Comparison Clock—Nardin 506

Date—Jan. 10, 1925
Time—3 p.m.
Observer—R. M. S.

Clock	Station	Clock	Station
22 20 7+	1	22 14 45.5?	Preliminary
21 5+	60	15 35.5	Preliminary
22 4+	120	22 20 42.5	36.5
23 3+	180	21 32.5	87.5
24 2+	240	22 23.5	139.5
25 0+	300	23 14.5	191.5
		24 6.0	244.0
		24 57.5	296.5
			51.00
			.98077

Comparison Clock	Sidereal Clock
22 13 0	22 12 55.999
28 0	27 55.987

Comparison Clock	Wireless Station	Sidereal Clock	
22 22 49.417	165.917	22 22 45.410	
		2 11.505	
	λ Ottawa →	5 2 51.940	
03.22.31.99			App. ΔT
03.27.25.24		3 27 48.855	—
		4 53.250	
	1	3 22 55.605	−23.61
	300	3 27 48.855	−23.62

EAH 2000
8/3/24
9-10 .980768

The two reproductions shown herewith are facsimiles of actual records, one of signals from Annapolis, the other from Lafayette (Bordeaux), showing the method used here for recording the signals and reducing the results.

On the Annapolis (NSS) sheet, the first section shows the observation record. The first two columns give the comparison chronometer times (approximately) of the Annapolis even minutes;

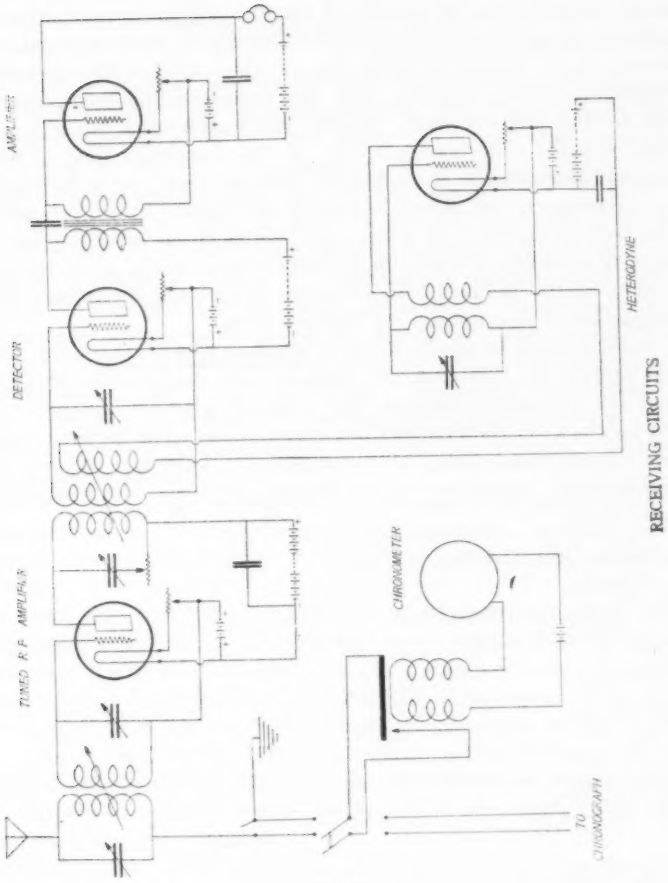
AMPLIFIER
DETECTOR
TUNED R.F. AMPLIFIER
CHRONOMETER
HETERODYNE
RECEIVING CIRCUITS
TO CHRONOGRAPH

Fig. 2

the third column contains the times of the observed coincidences, also by the comparison chronometer, while in the fourth are the corresponding Annapolis times deduced from the foregoing. The second section gives the results of the chronographic comparisons (each the mean of ten scalings) of the chronometer with the standard sidereal clock. In the third section are the means of the observed coincidence times, together with the corresponding interpolated time by the sidereal clock. Immediately under this is the computed sidereal time corresponding to the Annapolis time of the mean of coincidences; the difference between these two is therefore the correction to the sidereal clock as determined from this particular set of signals. A subsequent comparison with the same quantity as adopted from the Ottawa observations, after taking account of the published Washington corrections, completes the comparison of Washington and Ottawa time.

Similar remarks apply to the Lafayette sheet, except for the final steps. In this case the computation deduces by obvious steps the Greenwich sidereal time (according to the uncorrected Ottawa clock) of the first and last signal beats. Comparison with the corresponding times as wirelessed by Lafayette gives the (preliminary) correction of the Ottawa clock as determined at Paris.

Dominion Observatory,
Ottawa,
January, 1925.

THE DOMINION OBSERVATORY ECLIPSE EXPEDITION

By R. Meldrum Stewart

There are three classes of problems connected with total eclipses of the sun. The first class deals solely with the times of the different "contacts" of sun and moon, the second with physical conditions on the sun (chromosphere, prominences, corona), the third with the effects of solar radiation on the earth.

The problem of "lunar theory," dealing with the motion of the moon, is one of the most abstruse in astronomy, and has not yet been fully solved. Though it is possible to compute with great exactitude the effects of all known gravitational forces, the moon apparently refuses to be absolutely bound by them, exemplified by the fact that it was several seconds late in keeping its appointment with the sun on January 24 last. Hence the observation of the "contacts," or instants of beginning and ending of the partial and total phases of an eclipse is important for throwing light on these obscure deviations.

Phenomena of the second class are present at all times, but it is difficult, and in the case of the corona impossible, to study them except when the full glare of sunlight is cut off at the time of eclipse.

Problems of the third kind deal mainly with magnetic and wireless effects. It is well known that obnormalities in solar radiation, such, for example, as those connected with sun-spots, have a very marked effect on terrestrial magnetism. It is also considered that solar radiation, through ionization of the upper atmosphere, has a good deal to do with conditions affecting transmission and reception of radio signals. It is therefore of importance, in both cases, to examine into the results of the cutting off of this radiation at times of eclipse.

In the case of the eclipse of January 24 it was known that conditions for visual or photographic observations would probably be quite unfavourable, both on account of the low altitude of the sun, with accompanying atmospheric disturbances, and because

the chances were about two to one against a clear sky. It was therefore decided that the Dominion Observatory party should concentrate its energies principally on magnetic and wireless effects, while an attempt would also be made to observe the times of contact if the weather should be clear. This seemed the more rational since a co-operating party from the University of Toronto was making plans for photographic records of the corona, so that by the two Canadian parties practically the whole range of investigation was provided for. Both parties were located at Long's Corners, a few miles south of Hamilton, in the middle of the belt of totality. As it turned out, clouds entirely prevented all the visual and photographic observations planned.

The magnetic observations were distributed over three days, exactly the same programme being followed on the day of the eclipse and on the preceding and following days, so as to afford a basis of comparison. Readings of magnetic declination (variation of the compass) were made every minute for about six hours on each day. The instruments and observers were housed in a large tent partially heated by a non-magnetic copper stove. Similar observations were made by other organizations at various points both within and without the zone of totality. Until all these observations have been reduced and compared it will be impossible to definitely disentangle the eclipse effects, if any, from the constant variations to which the magnetic elements are always subject. All that can yet be said is that certain deviations from the normal curve showed themselves about the time of the eclipse, somewhat similar to effects that have been found at previous eclipses.

This was the first occasion on which eclipse effects on wireless receiving conditions have been investigated by scientific methods. As was perhaps to be expected in a first attempt, there does not appear to be a thorough agreement in the conclusions arrived at by all investigators. So far as the Dominion Observatory party is concerned, the general conclusion is that the shadow of the moon exerts the same kind of influence on radio reception as does the shadow of the earth; that is, the effects approximated to night conditions. On concert wave-lengths, where the most marked night effects are shown, the eclipse effect was also greatest; on both shorter and longer waves the effect was not so marked.

Besides the Director, the Observatory party consisted of Messrs. French and Madill, who took the magnetic observations, and Messrs. Henderson and Harrison, who conducted the wireless investigations.

Dominion Observatory,
Ottawa, March, 1925.

THE TOTAL SOLAR ECLIPSE OF JANUARY 24, 1925

Observers, far and near, have sent accounts of what they saw during the eclipse. Notwithstanding the cloudiness in Ontario, many of the observations are interesting, especially those of the shadow bands and of the meteorological phenomena, and in some cases appear to be even valuable. The order in which they are given in the following transcript is from west to east, in agreement with the course of the moon's shadow:

Mr. G. P. Morse, writing from Winnipeg, where the eclipse was partial, says: Reports on this eclipse from localities where it was not total may be useful that they may be checked up or combined with others.

The partial eclipse at Winnipeg surprised the writer by its unexpected duration. Owing to slight cloudiness the sun was not actually visible from a moderate elevation till 8h 14m Central Time when a few seconds after the first gleams there were indications that we were really to see the eclipse. At 8h 15m the sun appeared to be covered to the extent of two-thirds. By 8h 35m it still appeared half covered. By 8h 55m the obscuration could still be detected by an intent look for a second without smoked glass; and it was not until approximately 9h 07m an examination by smoked glass showed the writer no trace of the moon.

Mr. J. B. Chapman of the Customs Department, who has a large radio set, tells me there was *a roll*, somewhat between an organ and the breakers of the sea, going through the set until the eclipse was well advanced—a comparison that suggests auroral phenomena.

I expected a period of greater darkness between 7 o'clock and 8 o'clock than had existed at 7. This was not actually confirmed. But between 7h 45m and 8 o'clock I traced a much darker band than most of the sky itself at that hour, extending from approximately the location of sunrise over toward the west. This did not rise vertically, but lay across the southern part of the sky, from the east to not much past the meridian and became almost suddenly prominent, with the western sky naturally still pretty dark; the

band had an elevation on the meridian not exceeding 40 degrees, probably when most well-defined not more than 20 degrees. If attributable to the umbra itself which we were not to experience, this band should, except for perspective, be narrower in the meridian than at the east end. Actually it appeared wider at the west end, the sides being straight and rather clearly defined. But the general brightness of the sky was gradually increasing all the time. I could not give this steady attention. The apparent thickness, approaching ten degrees, would discount the idea that it was made up of intermittent shadow bands; I believe it was the umbra as it swept near the international boundary line.

A correspondent who viewed the eclipse at St. Mary's, Ont., writes:

Situated as we were quite close to the centre of the shadow belt a number of us went out about 7.50 a.m. to a vantage point but *old sol* was completely hidden by heavy clouds. Later a glow indicated its position with patches of blue breaking through farther west about nine o'clock. Then the clouds parted and we had a splendid view of the sun just before totality. It had grown very dull, and the west appeared as one sometimes sees it before a very severe storm. The silence was intense with no wind. A further rift in the clouds, and for about thirty seconds we were spellbound by the beauty of the corona and the weird effect of darkness just at 9.05 a.m. as well as the presence of a few stars. Jupiter and Venus were quite distinct. Nothing could be distinguished on the moon—just a black blur in front of the sun. The corona was marvellous and reminded me of a rainbow in which orange colours predominated. The birds (sparrows) were hopelessly bewildered and moved as they do when disturbed into flight after dark. The dogs were the only other animate objects and they were inclined to whine a little and cringe at your feet. It was suddenly bright again and the moon gradually moved across the sun from west to east. The last half was very distinct and it was nearly ten o'clock before *old sol* could be fully seen.

Another correspondent, J. J. Brown, writes from St. Mary's, Ont., of having witnessed the eclipse under circumstances similar to those of the preceding correspondent:

I had a fine view of the eclipse on Saturday morning. Just before the time of the total darkness the sun broke through the clouds and I saw the corona very clearly, but the shadow bands were invisible.

Mrs. A. G. Atkinson of Tilbury, Ont., which is about sixty miles to the southward edge of the shadow belt, and where it was not possible to see the total phase, writing to her husband in Toronto, states that she saw "the shadow bands" as the moon began to recede. Her own account continues thus:

This was a surprise for me, as I did not know one would see them at any place other than where the eclipse was total. As it reached its darkest point here, I was watching the sun and for perhaps a minute and a half kept observing it. Then I turned my attention to the north-west and you can fancy how pleased I was to see the long shadows cross from west to east across the field opposite the house. They came in a series of rippling tremulous movements, with a few seconds between each series, and as the light grew stronger appeared to diverge as from the handle of a fan always moving quickly from west to east. I could not judge them very well, but I think the display lasted for four or five minutes from the time I saw them and I cannot tell when they started. It was magnificent. For when I first saw the shadow bands there was such a soft grey light, quite unlike either a dawn or late twilight at night. The fine bit of sun served to produce a fine tone of light.

Mrs. Lina Schrag writes from Brampton, Ont., as follows:

I did not have a glass, but with an unobstructed view of the sky I was able to watch the part of the sky through which we should have seen the sun travelling on a clear day and at the same time the appearance in other quarters.

Up to twenty minutes to nine there was nothing to see that might not have been observed on an ordinary cloudy day. Then I noticed that in the north, and extending about one-fourth of the way to the west, the sky became inky, as it does before a bad summer thunderstorm. At the same time a pale clear orange light appeared to the north, or left side of the sun, and spread out in a large circle, slightly above where I judged the sun to be. As

this light became more apparent on the left side, the lines of which I spoke (in *The Telegram*) began to appear on the right side.

At first I thought they were telegraph wires, but reminded myself that there are no groups of wires in the part of the town where these appeared. They were very clear, like pencil lines on a gray card, the one lowest in the sky extending very far to the west, the others not so far, but ending as if cut off on that side. The distance between the lines gave the impression of telegraph wires, and I should say, although, not having a glass, I cannot state exactly, that there were from 20 to 30 of these lines the first time I noticed them. There were not so many of them the last appearance.

Altogether these lines appeared and disappeared seven times. The last time they were a little closer together and sharper in their outline against the sky, but did not last as long, as the sky was then beginning to darken with the eclipse.

The lines appeared to separate in this manner: As if the bands of gray between them widened evenly, and pushed the black lines apart. There was a wavering, not in the lines, but as if the gray colouring came closer to the earth and receded in a regular rhythm, slow and majestic. Of course, I am merely telling of the thing as it appeared to me, and as I told myself in words what seemed to be happening.

The last appearance of the lines was a very short one, and the bands became only one-fourth of the width the first ones had been as they pushed the black lines apart. They then faded into the deep shadow that came over the sky.

At five minutes after nine there was a spectacle that I shall never forget. For a short space, perhaps for as long as it would take one to count five slowly, the sun seemed to approach the earth. The clouds did not seem to become any thinner; it was as if the sun were stalking towards the earth in an angry mood. Just as if a curtain of thick gray mist opposed itself in the path of the sun, and the sun were determined to overcome an enemy, it marched towards the earth. A circular mass of light of a flaming orange appeared. The edges of the circle were slashed and jagged, two long points of light rising high above the central mass. One was near the centre, the other to the right side. Exactly opposite,

in the western sky, at this moment, a false dawn was to be seen, and even when the eclipse was at the height a pale light continued in the west.

In an instant, as if the sun suddenly stepped back behind a thick curtain of mist, the orange light that had persisted to the left of the sun disappeared, and the twilight of the eclipse spread. When this was over, all orange light disappeared from the sky, which again showed the mere gray of a cloudy day.

Mrs. Nellie Rankin Sissons writes from Barrie, Ont., which was outside of the shadow belt, of the observation (at 9 a.m.) of "alternate wide bands of light and dark gray lifting for a second to show faint colours as of a rainbow, their long, wide, light and dark bands stretching from north-west to south-east." Photos taken at the time, especially one at 9.06, just at the time of the beginning of the total phase to the southward, show the phenomenon indistinctly, but too faint to bear reproduction in print. The Winnipeg correspondent mentions a similar feature (see above).

John Rigby of 22 Milverton Boulevard, Toronto, writes of observing the "shadow bands on clouds" as follows:

I was proceeding down Jones Avenue toward Danforth Avenue when, on looking up to the sky about 8.55 a.m., my attention was drawn to most peculiar streaks in the clouds. They appeared to be travelling at a very fast rate, the appearance of which put me in mind of a receding tide on the sea shore, *i.e.*, upheavals of the sand and a gradual fall after each upheaval. (His diagram also suggests the "shadow bands.")

A. F. Hunter, who observed at Welland, Ont., near the centre of the shadow-belt, writes:

As the eclipsed sun became smaller, the sky, wherever it could be seen through the rifts in the clouds, took a deeper blue, and just before the total darkness the sky, so far as it could be seen at all, was of a very deep shade of blue.

Totality began at 9.06 and lasted till 9.08 a.m., so far as it was possible to judge of the time, with the canopy of clouds intervening. During this two minutes ordinary print of any kind could not be read, but the hands of a watch, with a wider interval than print,

could be seen. The rifts in the clouds, visible until totality or nearly so, then ceased to be visible. The shades of twilight and night prevailed wherever it had been possible to see the blue sky in patches. But they were not exactly the shades of evening, they had peculiarities of their own. The darkness of the clouds itself had a deep blue cast which it must have drawn from the sky.

As soon as the shadow had come over—southward and northward on the distant horizon—fifty or sixty miles distant—at the front of the shadow there were patches of amber-coloured light—the sunset colour that prevails in winter. The reverse, with less distinctness, occurred as the shadow departed. In other words, the shadow of the moon on the ground was circular, or, speaking more correctly, conical, and the effects seen in the four directions were ocular proofs of this.

Ordinary golden sunlight is the complementary colour of the blue sky. If one could see the sun without having its light sifted through our atmosphere it would be a brilliant white. It approaches this colour as one climbs to the tops of high mountains. The amber tint of the horizon (and this was the only moment when the horizon in the direction of Toronto was lighted up during the whole morning) was the ordinary white sunlight with the blue of the spectrum omitted—in other words, the complementary colour of blue, caused by cutting it out of the spectrum. This can easily be proved by the rotating spectrum disk. As the blue colour of the sky was deepened by the darkness so was the golden sunlight on the horizon deepened into the amber colour.

Many of the features that belong to an eclipse occur with every ordinary sunset and sunrise, an eclipse being only a sunset of a special kind. The eclipse obviously created some of the cloudiness or precipitation of water vapour into clouds. A similar instance may be found in Prof. John Tyndall's "Fragments of Science," in the chapter on "A Voyage to Algeria to see the eclipse." He states that the shade of the eclipse produced the clouds.

Altogether, a total eclipse of the sun, like this one, was a weird sight for the two minutes of darkness. One can easily understand how an uneducated people, without knowledge beforehand of such an event, could be frightened out of their senses.

George H. Stevens, Arthur S. Lawson and Percy S. Boughton, engaged in business at Newark, N.J., the first a chemical engineer, the other two civil engineers, write as follows respecting the shadow bands seen during the eclipse:

The three of us observed the eclipse on Saturday morning, January 24th, 1925, at a point about lat. 40° 56′ 48″ N., long. 74° 16′ 30″ W., according to the U.S. Geological Survey, Morristown Sheet, just north of Paterson N.J.

We chose a country road on a hill, to the east of which was a dazzling white level stretch of snow, much more than 5 acres in extent and with nothing to interfere between us and the sun during our observation. To the west was a range of hills about 5 miles away though some trees interfered between. Our aim was to see the black shadow advance from the west over these hills and at the same time watch for the "shadow-bands" on our beautiful snow sheet at our feet and lying east of us, and which did not have a bush or foot mark on its entire expanse to break its level surface. The sky was beautifully clear and a common thermometer indicated 10° F. when the eclipse was at totality. Just prior to totality we saw everything grow darker but failed to catch the great shadow as it approached, possibly because of the trees between. But we did see, immediately upon totality, the most marvellous display of "shadow-bands" on that wonderful snow-white blanket spread before us, that could have been prepared for the most exacting scientist, and we all decided to repeat our impressions of it verbally several times while it was still clear and distinct in our minds.

We had read of the "shadow-bands" and about the requests for their width, direction, speed, etc., and we were unconsciously prepared to see something that might be counted, or guessed at in width, or defined as to light and dark, or distinct, but what we saw instead was totally different and we do not believe that many observers with conditions less auspicious than ours were could have seen them as we did.

The "shadow-bands" immediately upon totality shot across our 5 acre expanse with express-like rapidity in broken waves or ripples, paralleling each other and the sides of these ripples advancing toward the sun (east). We did not time their duration, but our impressions are a maximum of 15 seconds or a minimum of

10 seconds for the total duration of the first phase or flood of them.

Again, just before totality was to cease, the same remarkable phenomenon was repeated, but much to our surprise the bands paralleled east and west and, in broken ripples, moved north this time instead of east. So pronounced was the change in direction that the impression is in our minds of their being in approximate right angles to the first flood of them and unmistabkaly moving north,—the speed, intensity and other characteristics, exactly like the first case and of the same total duration.

The strongest display of the bands in the first phase was immediately after totality had commenced, and then a gradual diminishing of them until they disappeared, and of a total duration of the estimated 10 to 15 seconds.

In the second phase this was reversed and the faint ones came first and increased in intensity until maximum, and ended when the point of dazzling sun-light burst over the edge of the moon at the end of totality. Their total duration was substantially the same as in the first phase.

As to the number to a yard, or the number to a second, no human eye could even guess at, as it was far above railway speed and in such broken parallels as to be hard to define in any way.

Our position of observation was at the immediate edge of our white snow blanket, no fence between us, and as the snow was deep we were more than ordinarily close to our shadow ground, and yet we could not distinguish these shadows more than 40 to 50 feet away, that is they were unobservable at a greater distance from us than that because of their indistinctness, and had one been in any kind of an air craft they could not have seen them on the snow even with very strong glasses, if at a point above the place where we were standing. Neither on any surfaces available in such air craft could they find sufficient area to be very likely to even observe them.

The first set of shadow bands we observed only as moving away from us, for we did not look behind to see their coming and our clear field was only in front (facing the sun). These bands faded out of our range of sight in from 40 to 50 feet away.

The second lot of shadow bands, coming from the south and moving past us, could be seen both coming and going, but over a total distance not twice that of the first observation. We mean by the above that our eye-sight was not able to discern the bands more than 40 to 50 feet away, even with our wonderful lay-out, because of their indistinctness.

One of our observers described the phenomena of the bands as giving the optical impression that one receives when observing the fine spray from rain, falling on the ground and being driven in fine gusts in a given direction by a high wind.

I would say that it left the same optical impression as of a heavy wind blowing an exceedingly fine snow as it fell, and in infinitesimally fine gusts, that would strike the fine drift surfaces on the ground and break up over the parallel ridges.

These drifts paralleling each other, broken, but moving sideways in the directions mentioned, and moving all over the surface of smooth, plain white expanse of ground that permitted of this optical display or delusion.

The so-called "shadow-bands" of our eclipse (first phase) were not "shadow-bands," but were instead reflected light shades that dispelled the would-be shadows or shadow bands, causing them to melt away eastward, but the shadow or shadow line forming again in the rear (west) to melt again eastward again and again with lightning rapidity.

The second phase was like the first, only reversed in intensity.

The description of "dancing shadow-bands" sometimes given is wrong, for dancing means an oscillation, either up or down, or back and forth. No such oscillation occurred in the slightest degree or manner.

No shade of light or dark reversed its direction at any time, but instead, wave after wave, rank after rank, and area after area of them swarmed up and across and all going in exactly the same direction and all in parallels but greatly broken.

They were parallel and broken strata of light (faint light) chasing the shadow or shadow lines rather than shadow-lines advancing on the light snow surface.

Unquestionably no sharp or even distinct lines of light or dark presented themselves, but faintly varying degrees of light in irre-

gular or broken parallels or ripples flitted past with express-like speed, and simply masses of them.

The difference in their shade was scarcely discernible, and yet, as a whole, they created the peculiar optical delusion of actual gusts of shortish, narrow, faint, light and dark parallels.

If one did not have the wonderful large white ground on which to observe them, we fail to see how they could observe much of them, as they were so fleeting, so speedy, narrow, broken, faint, and yet so parallel and definite in their direction.

We had spread before us a segment or area, the radius of which was 40 to 50 feet, completely covered by the phenomena for from 10 to 15 seconds, and then again repeated, we standing at the angle. Beyond our arc the "shadow-bands" were not discernible to us. That is, our eyesight was not able to further follow them.

Most astonishing to us was the two sets moved actually at approximately right angles to each other, the first travelling easterly and the second northerly.

We made no record of time or other factors because of the cold, though we did note that at approximately the middle of totality that it was 9h 9m a.m. We did receive a very vivid impression of the "shadow-bands."

We believe that the direction of the bands will be different with each different eclipse and that the appearance of the bands will be different in the same eclipse, according to the position of the observer in relation to the centre or to the outside edge of the disc of totality. And even that on the same concentric ring of the disc of totality that different observers will see the bands differently as to appearance depending on what portion of this concentric ring they may stand.

The further within the disc of totality (towards its centre) the fainter the most of the bands would naturally be; and inversely, the nearer the edge of the disc of totality the more pronounced the most of the bands would be.

Writing from Cambridge, Mass., Wm. C. Turney, S.S.J.E., amongst other remarks on the eclipse, says:

The N.Y.N.H. and H. Ry. ran special trains to Westerly, Rhode Island, for people from Boston who wished to view the eclipse

within the region of totality. Trains were announced for 5.45 a.m. and at 6.05 a.m. and at later times. On the 21st at 7 p.m. accommodation on the later trains was no longer available, and so I bought a ticket for the first train. The trains ran in six long sections carrying altogether perhaps 2,500 persons. At 7.18 a.m. the sun was up and I was able to see it clearly from the windows of the train, although the sky was mottled with small clouds.

At 9.08 a.m. the crescent was slender but intensely bright as seen from a large open field at Westerly, known as Foster's Grove. At 9.12 a.m. the crescent was shortening rapidly. The shadow-bands could now be seen very distinctly on the snow. They seemed to be parallel, wavy lines extending nearly north and south. My impression was that they consisted of light and dark lines and that the dark lines consisted of alternate dark and light patches or links. Each line was perhaps an inch and a half in width, the dark and light lines being equal in width. The dark and light patches or links which made up the lines might have been two inches or more in length. The lines were moving, with much quivering to the west at a uniform rate.

Bailey's beads were not noted with any accuracy. At 9.14½ totality had begun. The temperature at this time was announced to a group of people as 3° F. I did not see any approaching shadow as the moment of totality arrived, but from 9.10 until the beginning of totality the darkness fell very rapidly. There was a bright fiery ring showing all around the circumference of the moon, probably the chromosphere and prominences. It was so bright for a moment it seemed to call for the use of smoked glass. The corona completely surrounded this fiery ring and was somewhat elongated from east to west. It terminated in three rays or tongues to the westward and three to the eastward. It had the appearance of a light filmy cloud thinning out toward the edges and the tips of the rays. Its inner part was illuminated by the fiery ring. At 9.15½ the light began to increase and at 9.16 the crescent of the sun would have measured perhaps 90°. Faint shadow-bands were seen quivering on the surface of the snow. At 9.18 I overheard the temperature announced to the same group as before. It was now 6° F.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

SCIENCE AND LIFE

The following article from the *New York Times* expresses so well the influence exerted by science upon the deepest and most abiding things in life that it is reprinted here.

Perhaps few stop to reflect about the attitude of millions of people toward the eclipse of the sun, and to ask themselves what it is that has made this differ so wonderfully from the mental state of those human beings whom such a natural phenomenon used to fill with superstitious fears. It is one of the beneficent works of science. An attribute of true science is the power of prediction. That has been exemplified in a way which all can understand in the case of the eclipse. Its beginning, duration and ending have all been minutely forecast. Everybody has implicit confidence in the accuracy of these conclusions of astronomical mathematics. Going behind technicalities, what is it that has been done for the world, in this particular, except to give it the truth, to furnish a complete explanation of a natural event? Knowing in advance the thing that will occur, accepting reasons given for its occurrence, people face with curiosity and keen interest, but without a particle of dread, what in other ages and other climes would have stricken terror to the hearts of great multitudes.

The whole is a good illustration of what science has done, or is endeavouring to do, in a thousand other fields touching upon human life. It is forever in quest of the truth. It seeks to ascertain and to make known to the common intelligence the why and the wherefore of many things that have been regarded as impenetrable mysteries. With every conquest, it not merely enlightens the minds of men, but gives them more confidence, more calmness in the face of the unknown, and banishes haunting fears that have long afflicted mankind. We speak with propriety of the blessings of applied science, but we ought not to forget the great boon which theoretical science has been to the human race. When we note and read of the temporary veiling of the sun in full accord with the scientific prophecy, we should be moved to give a grateful thought to the vast revolution in man's outlook upon the universe which has been wrought by scientific workers in unnumbered laboratories and experiment stations. They have added immensely not only to the safeguards and comforts of life, but to its dignity, its intellectual satisfactions, its assurance that the process of the suns will go on majestically. The endless and sublime search for knowledge which has

marked the strivings of star-eyed science has lifted the minds of men to a level where they can feel secure and affirm that it would be a shame to stand in God's creation and doubt truth's sufficiency.

ISLAND UNIVERSES AGAIN

The view that some of the great spiral nebulae are other universes, far in the depths of space and hence appearing so small, has been given new life by the recent investigations of Dr. E. P. Hubble, at the Mt. Wilson Observatory. He has deduced the following facts regarding the Great Nebula in Andromeda:—

It is so distant that it takes light nearly a million years to travel from it to the earth. That is, it is some 6,000,000,000,000,000,000 miles away. It is the most distant object known to science. It is as large and has as much material in it as our own galaxy. Its total light is one billion times that of the sun. It contains some three or four thousand million stars. In shape and form it is not unlike the great stellar system or galaxy of which the Milky Way and most of the stars we see at night are a part and in which the sun and its revolving planets are but pin points. It is at four times as great a distance as ever previously established for any celestial object, with the exception of the faint star cloud N.G.C. 6,822, which Dr. Hubble has shown to be 750,000 light years from the earth. It is an "island universe", a concentration of stars, gaseous material and perhaps even planets, out in the space of the great all-inclusive or super-universe and billions of miles away from other universes or galaxies like our own. And the spiral in the constellation Triangulum seems to be nearly a twin to that in Andromeda.

How can evidence of such gigantic "universes" be obtained? First of all Dr. Hubble's photographs, better than any previously obtained, showed "dense" swarms of actual stars" in the outer parts of spiral nebulae. Then it was found, by taking photographs night after night, that some of these stars were what is called Cepheid variables. They fluctuate in brightness, going through a period of sudden rise to brilliance and slow fall to dimness in times ranging from a few hours to 50 days. At maximum they range from 4,000 to 8,000 times the sun's brightness. This was the clue to the determination of the great distance of the nebulae.

Some years ago Dr. Harlow Shapley, of Harvard, worked out a useful relationship between star brilliance and the period of these Cepheid variables, so named because they are most prevalent in the constellation of Cepheus. He found that if the period of variation was known, the absolute brightness, dependent only upon the temperature of the star and not upon its distance from the earth, could be determined. A simple comparison of absolute brightness of the star with the brightness shown through the telescope tells the distance of the star from the earth.

When Dr. Hubble applied this law to the variable stars he discovered in the Andromeda nebula, he found that they were all about 930,000 light years away in another island universe.

AN ECLIPSE BABY

The following article is taken from *The Trenton Courier-Advocate* of February 12, 1925, and explains itself:—

Mr. and Mrs. Geo. Leavey were honoured on January 24th, by the arrival at their home of an infant daughter. C. A. Chant, of the Department of Astronomy, University of Toronto, who was much interested in the eclipse of that day and was sorely disappointed at not being able to secure proper photographs of the event on account of cloudy weather, was addressed by the parents in sympathy at the loss sustained to his profession and requested at the same time that he name the child in remembrance of the eclipse. The following is the professor's reply:

University of Toronto,
February 10, 1925.

Mrs. George Leavey,
Trenton, Ont.

Dear Madam: I thank you for your kind words of sympathy for us in our failure, through cloudy weather, to obtain photographs of the recent eclipse.

I wish also to say that I feel honoured in being asked to select a name for a dear little girl, which was born on the morning of the eclipse.

The name I would suggest is Helen Corona. "Helen" is from the Greek and means "Light", while "Corona" refers to the beautiful crown or halo about the sun, which we were not allowed to see at the time of the eclipse.

May the light of intelligence always guide the dear child along the pathway of life, and a crown of goodness ever encircle her brow.

Very sincerely yours,

C. A. CHANT.

On February 28th, Dr. Chant left for New York on his way to Italy and Egypt, where he will attend the International Geographic Congress to be held in Cairo. He will return by way of Athens and Rome and will attend the meeting of the International Astronomical Conference to be held in England in June.

MEETINGS OF THE SOCIETY

At Toronto

December 5, 1924.—The 2nd Vice-President, Mr. A. F. Hunter, in the chair.

Mr. Hunter drew attention to some recently determined distances of nebulae by Hubble, which would seem to place the spiral nebulae at distances away beyond the confines of our galaxy whose outlines are indicated by the extremities of the Milky Way.

The lecture of the evening was by Prof. R. K. Young, Ph.D., of the Department of Astronomy of the University of Toronto, on "The Total Solar Eclipse of Jan. 24th, 1925".

Dr .Young gave a general outline of eclipse phenomena, illustrated with lantern slides, and emphasized the useful work that amateurs might do. In photography a camera of 20 inch or more focus should be used or the image would be too small, and on the plates standard squares should be placed, as is usual in photometric work in astronomy.

January 27, 1925.—The Annual "At-Home" of the Society was held in the Physics Building at 8.15 p.m. The Vice-President, Mr. A. F. Hunter, was in the chair.

Mr. Hunter indicated the names of the newly elected officers of the Society which appeared on the printed programmes and went on to trace the growth of the Society from the time when its few members met at private houses, to its present proportions, extending from the Atlantic to the Pacific.

He then called upon the President, Mr. R. Meldrum Stewart, to address the meeting.

Mr. Stewart's address was on "The Year's Progress in Astronomy". In it he congratulated the University of Toronto on their good fortune in obtaining the services of Dr. R. K. Young as Associate Professor in the Department of Astronomy. He then reviewed the work done during the year at the Dominion Observatories at Victoria and Ottawa, the observations made of the planet Mars on its close approach to the earth in August last, and outlined the work of Russell and Eddington in connection with the theory of stellar evolution.

After Mr. Stewart's address Mr. H. C. Bates demonstrated an apparatus arranged by Dr. H. C. McTaggart for mixing light of different colours.

Dr. L. Gilchrist, by means of experiments and lantern slides, showed some of the properties and uses of X-rays.

In the North lecture-room Dr. John Satterly exhibited some of the

properties of liquid air. He took its temperature, 331 degrees below zero F., by means of a pentane thermometer, showed its effect on mercury, india-rubber and other substances and performed many interesting and unusual experiments.

Refreshments were then served, after which the meeting adjourned.

February 10, 1925.—The Vice-President, Mr. Hunter, in the chair.

The following were nominated for membership:—F. McK. Paterson, Whitechurch, Ont.; Elman Campbell, Newmarket, Ont.; Mrs. Margaret Stewart, Langstaff, Ont.; W. W. Hood, 402 Delaware Ave., Toronto; Mrs. Will Douglas, Athelma Apts., Grosvenor St., Toronto; J. R. Gibbs, Grimsby, Ont.; E. L. Young, 311 Goyeau St., Windsor, Ont.; Gerrit J. Bennett M.D., 705 Black Bldg., Waterloo, Iowa; Walter J. Helm, Port Hope, Ont.; R. H. Spurway, Box 725, Nelson, B.C.; Jos. L. Van Assel, Raymond, Alberta; J. L. Eaton, Grimsby, Ont. As some of these names had been received for some time, it was moved by Dr. Chant, seconded by Mr. Miller, that the by-law requiring nomination to be two weeks before election be suspended, and that the Secretary cast a ballot in favour of the election of the candidates. The motion was carried.

Under prediction of phenomena, the chairman mentioned that Neptune was in opposition on Feb. 10th, and that Saturn, Jupiter, Venus and Mercury were morning stars. He remarked also on the unusual circumstance that Mercury had for three weeks been farther from the sun than Venus. Dr. Chant mentioned that he had received an inquiry from Dr. Geoffrey Bell, of Brantford, as to the time of maximum of Mira. A calculation by Chandler's formula gave Feb. 7th. At Long's Corners, in looking for a good star to sight on to adjust the coelostat, Dr. Young happened to strike upon Mira. He judged the magnitude to be about 4½ then.

A question was asked by Mr. Wm. Gore in connection with the lecture by Dr. D. C. Miller of Cleveland on the subject of ether drift; the lecturer said that the drift calculated from experiments performed at Mt. Wilson was about one-third of the anticipated amount. The question was, What was meant by the anticipated drift? Dr. Chant explained that the drift was indicated by a displacement of interference bands, and that it had been possible by means of various known facts to calculate what displacement should be expected. He believed, however, that no definite conclusion had been reached as yet.

The chairman then called upon Dr. R. K. Young to address the meeting, his subject being "Some Features of the Eclipse of January 24th".

Dr. Young spoke of the various expeditions sent to observe the eclipse and their success. At Long's Corners, near Hamilton, the expedition from the University of Toronto aimed to secure:—

1. Photographs of the Sun 5 inches in diameter with various exposures on plates upon which standard squares had been imprinted.

2. Photographs through Nicol prisms and screens of different colours.
3. Photographs of the spectrum of the flash and of the corona.

The darkness came within a few seconds of the appointed time, but as the sky was cloudy it was impossible to obtain any photographs. This was the case over practically all of Ontario, only a few observers in western Ontario being fortunate enough to see the corona through rifts in the clouds. In Buffalo conditions were poor, but from Binghampton to Rhode Island a good view was obtained. At Ithaca, N.Y., an expedition from the Yerkes Observatory, under Parkhurst, made complete observations; at Binghampton most of the programme was carried out. At Middletown, Conn., where expeditions from Mt. Wilson, University of Virginia, Harvard, the Bureau of Standards and other places had assembled, it was impossible to get the first contact but the rest of the observations were made. Although the astronomical party at Long's Corners was not successful, various other observations were made which will probably prove valuable. Magnetic observations were made by Messrs. French and Madill of the Dominion Observatory, Ottawa. Prof. Anderson and a party from the University of Toronto measured by photometers the intensity of the sky before, during, and after the eclipse. J. P. Henderson and F. Harrison of Ottawa, observed the variation in radio signals. Dr. Young read extracts of letters from different places relating chiefly to observations made of shadow bands. The reports of their width and speed seemed to vary considerably. In closing, Dr. Young said that the results obtained would appear from time to time in the periodicals, but owing to the great amount of material and to the fact that it means much work to measure accurately a single plate, it would probably be years before the completed results were available.

Several members mentioned having noticed that the light seemed to return after totality more quickly than it had departed, but no definite conclusion was reached as to the cause of the phenomenon.

Mr. A. F. Miller then addressed the meeting. He and a number of other members of the Society prepared to observe the eclipse from various points, several going with him to Hamilton, Mr. Hunter going to Welland and a number observing in and around Toronto. Mr. Miller arranged with various skilful artists to draw on a prepared plan their impressions of the corona, and if it had not been a cloudy day valuable results would have been obtained. Mr. Murray, who was assisting Mr. Miller, mentioned having seen what looked like a flash of lightning about the time of totality. Dr. A. D. Watson corroberated this statement.

Mr. J. R. Collins briefly described the reflecting telescope which he had prepared to use and showed some transparencies of the eclipse of 1900 made by the Lick Expedition. He had set up his instruments on the roof of the T. Eaton building and sheets were spread on the roof to assist in the observations of shadow bands.

G. M. BRYCE, *Recorder.*

At Montreal

January 9, 1925.—This being a joint meeting with the McGill Chapter of Sigma Xi and the McGill Physical Society, the chair was taken by Dr. J. B. Porter, President of Sigma Xi. The speaker of the evening was Prof. R. W. Wood of the Johns Hopkins University, Baltimore, Foreign Member of the Royal Society of London. The subject of the address was Invisible Light.

The lecturer explained how the human eye can see only a limited range of colours, the ultra-violet rays being just beyond one extreme of vision and the infra-red rays being just outside the other extreme. The presence of these invisible rays can be detected in various ways. Ultra-violet light affects a photographic plate very readily, and if all other rays be cut off by means of a quartz lens covered with metallic silver, and the landscape be photographed only by ultra-violet light, some curious effects are produced. The sky comes out very luminous since there is much scattering of these rays by the atmosphere, many bright objects appear quite black as the light reflected from them is wholly within the visible range, there are no shadows as the ultra-violet illumination is from these sky-scattered, diffused rays and therefore less directly from the sun than the visible rays which cast the pronounced shadows with which every one is familiar.

Photographs taken at the other extreme, the infra-red, show the sky very dark but foliage comes out quite white, giving very beautiful effects as though the trees were all in blossom.

These facts were made use of by the lecturer to develop signals during the late war. An infra-red flash lamp sent a narrow, intense beam of light which at a distance of twelve miles could be observed by a person wearing dark red goggles, but absolutely invisible to the naked eye. Utilizing ultra-violet rays and a phosphorescent screen the lecturer had in 1918 devised a method of signalling at night from ship to ship without the use of visible lights. An electromotive force of 8 volts was sufficient to send a signal 18 miles.

Illustrations were given of the possibility of painting two designs on the same object, one pigment giving a design visible to the eye if seen by daylight, the other design superimposed upon the first by a pigment invisible by daylight but alone visible if viewed through a special glass screen, which filtered out all the visible rays.

Applications of these methods of photography in astronomical work were then described and slides of the planets and moon were shown. Ultra-violet photographs taken by the lecturer's methods at Mount Wilson have disclosed markings upon the moon which suggest the presence of rocks with a high sulphur content, also interesting but unexplained markings about the polar and equatorial regions of Saturn were shown; but perhaps most interesting of all to the public at large, these photographs show that the hypothetical ice caps of Mars are an atmospheric phenomena, probably clouds or mist.

A Resonance lamp was next described, giving ultra-violet light by means of an electric discharge through a quartz bulb containing a trace of mercury vapour. If a photograph be taken by this light any free mercury vapour present

in the atmosphere absorbs the ultra-violet light and so appears black on the plate. An application of tremendous practical value has been made of this by the lecturer who has shown that in mercury turbine plants the danger which the employees run from mercury vapour poisoning may be overcome by testing the atmosphere at intervals by means of ultra-violet photography.

In conclusion, the lecture theatre being darkened, an ultra-violet lamp was set going and though invisible in itself it caused most objects about the room, the faces, eyes and teeth of the audience, to phosphoresce. Since the lens of the eye is itself stimulated into phosphorescence, the resulting sensation is very extraordinary as though a bluish haze were everywhere pressing in upon retina and brain. Various substances, solids and liquids, exposed to the rays phosphoresced with different colours, some of the effects being very beautiful.

The reward of scientific research, said the lecturer, is in the doing of it, the satisfaction which comes from solving some of the mysteries presented to the mind of man in the complex puzzle of all time—the great cross-word puzzle of NATURE.

In moving a very hearty vote of thanks, Dr. A. S. Eve referred to the revolution in thought which the past few decades have brought, due to the achievements of the small company of great thinkers and "exquisite experimenters", to which company Dr. R. W. Wood most certainly belongs.

The meeting then adjourned.

A. VIBERT DOUGLAS, *Secretary.*

The Royal Astronomical Society of Canada

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